CHAPTER 2

DRY AIR SYSTEMS

For optimum performance of today's transmitting equipment, especially high-power radar systems and low-power satellite systems, some rigid coaxial cable and waveguides are required to be pressurized by air. In some waveguide systems, dry air is used primarily to increase the dielectric constant inside the waveguide to prevent rf energy from arcing inside it. Arcing causes damage to the inside of the waveguide, and it also reflects a short circuit back to the power amplifier tube. As a result, the power tube could sustain major damage. Also with the use of pressurized dry air, the problems of corrosion, contamination, collection of moisture, and oil droplets (which affect preservation) are decreased. At the same time, the overall reliability of the waveguide system is increased.

In high-power waveguide runs, the dry air pressure is approximately 20 to 35 psig. The increased air pressure increases the dielectric (resistance) strength of the air. Arcing is then less likely to take place.

In low-power waveguide applications, the dry air is approximately 1 to 8 psig. The dry air is used primarily to prevent corrosion and contamination inside the waveguide. These effects are caused mainly by moisture in the waveguide.

The number of equipments requiring dry air for operation has increased drastically in recent years. Central dry air systems have been installed in many ships to overcome the problems of individual maintenance, repair, and supply support required by individual air dehydrators. There are, however, a large number of individual equipment dehydrators still in use on many ships. They are now being used as a back-up systems should there be a failure in the ship's central air system.

ELECTRONICS DRY AIR

On ships having multiple dry air users, a dedicated dry air main is installed to support clean, oil free, dry air to pressurized coaxial cables, waveguides, and other electronic equipment. Supply to this main is from the vital main by way of type II or type III dehydrators installed in parallel so that one serves as a 100 percent stand-by for the other. In large ships with extensive air demands, four dehydrators are installed and the air main can be split for casualty control. The dry air main terminates at air control panels, which control and regulate pressure to the electronic user equipment. Four types of NAVSEA air control panels (type I [user pressure to 30 lb/in^2], type II [user pressure to 60 lb/in^2], type III [user pressure of 75 lb/in^2], and special [usually used where pressure flowrate is unused]) are available.

- Type I Panels: Typical users URA-38, WRT-1 and WRT-2, SPS-39, ULQ-6, WRL-1, SPS-40 waveguides.
- Type II Panels: Typical users SPS-40 cavity, SPG-51 and SPG-60.
- Type III Panels: Typical users require air at 75 lb/in^2 to equipment contained regulators such as SPG-55.
- Special: Typical users SPS-32 and SPS-33, SMQ-10.

In addition, equipment, such as SPS-48 and SPS-49, are supplied with panels designed for 80 to 125 lb/in^2. Each panel is equipped with a sampling connection, humidity indicator, flow meter, pressure gauges, and associated valves, to permit the user to monitor the equipment.

To ensure the reliability of the dry air supply to the electronic equipment, local dehydrators or local compressor-dehydrators may be provided. These local dehydrators are intended for emergency use when battle damage or casualties result in failure of the central supply system.

Several methods can be employed to remove excess moisture from the air. One method is by freezing the air by means of a refrigerant to remove the moisture. A second method is to pass the air through a desiccant, which absorbs the moisture. Some dehydrators use a combination of both methods to remove moisture from the air.

CENTRAL DRY-AIR SYSTEM

The ship's central dry-air system is usually located in one of the ship's main engineering spaces and can be composed of a low-pressure (100 psig) air compressor, a Type I dehydrator, and either a Type II or III dehydrator. The air compressor compresses the air and then sends it to the Type I dehydrator (refrigerant). The Type I dehydrator is used to remove the majority of the water and oil in both liquid and gaseous vapor forms from the air. Next, the air is processed by a Type II (desiccant) or a Type III (combination of refrigeration and desiccant) dehydrator to remove the last traces of moisture. This last bit of processing causes the air to become electronic dry.

DRY-AIR SYSTEMS

If you are involved with an equipment dry-air system, it is essential that you understand how to check the air for sufficient dryness. A high-power waveguide system requires dry air at a pressure of 25 to 35 psig with a dew point of -40°F at atmospheric pressure.

Dew point is the temperature at which water vapor begins to deposit as a liquid (at atmospheric pressure unless otherwise stated). For example, when the dew point is given as 40°F, this means that the excess moisture in the air will begin to condense at this temperature. Condensation appears as a fog or, if enough moisture is condensed, as ice crystals. The dew point is affected by the pressure of the air being measured. Air at 40°F dew point (atmospheric pressure) contains approximately 120 parts of water per million parts of air (ppm). However, this same air at 30 psig has a dew point of about –21°F. As you can see, you have to take into account the effects of pressure when you measure the dew point. The lower the dew-point reading (more negative/colder), the better the air quality.

The equipment air dryers installed in electronic equipment are desiccant dryers. The air is passed through a desiccant, which adsorbs the moisture. The more moisture the desiccant adsorbs, the dryer (lower dew point) the air becomes. You should know the basic operation of a desiccant air dryer so that you can perform PM and trouble isolation.

SHIP'S AIR SUPPLY

Air from the ship's compressor is often contaminated with water and oil in the form of vapor and liquid. The compressor compresses the air into a smaller volume causing the relative humidity of the air to increase. When the compressed air is saturated (100 percent humidity), it no longer holds any more vapor. Further compression causes the formation of liquid to begin. Also, since most compressors use some form of lubricant, it too can get into the compressed air as a vapor or liquid. The ship's dehydrators can remove all contamination, both liquid and gaseous vapor. In the event of a failure in the central dry air system, the small air dryer (if installed with electronic equipment) can be placed into operation.

EQUIPMENT DRY AIR

The purpose of the desiccant air dryer (fig. 2-1) is to remove oil and water in both forms, automatically and continuously, and to deliver clean, very dry air for pressurization of equipment waveguides. The air dryer is normally in the bypass mode. In this mode, input air is routed down through the selection valve and out of the dryer by way of the flow limiter. When placing the selection valve so that the dryer will process the air, you must first follow the dryer's start-up procedure.

This procedure ensures that wet air doesn't get into the waveguide systems when the dryer has been shutdown for an extended period. Basically, the procedure involves turning the electrical power on for the dryer and opening/closing of various valves to dump the air to the atmosphere. This is done until the dryer's air monitor indicates that the dew point is below 40°F at atmospheric pressure.

The operation of the air dryer is as follows: the input air (fig. 2-1) (selection valve is indicated) is first checked on the pressure gauge for minimum air pressure (typically 80 psig). Input pressure that is too low inhibits the operation of the fluid separator.

The fluid separator extracts most of the free liquids from the airstream. Some oil and water mist, however, (extremely fine droplets) remain in the stream. The liquid, thus collected, drains into the dump trap below the separator. When a sufficient amount has collected, the trap automatically opens to discharge the collected liquids under pressure into a waste line for disposal.

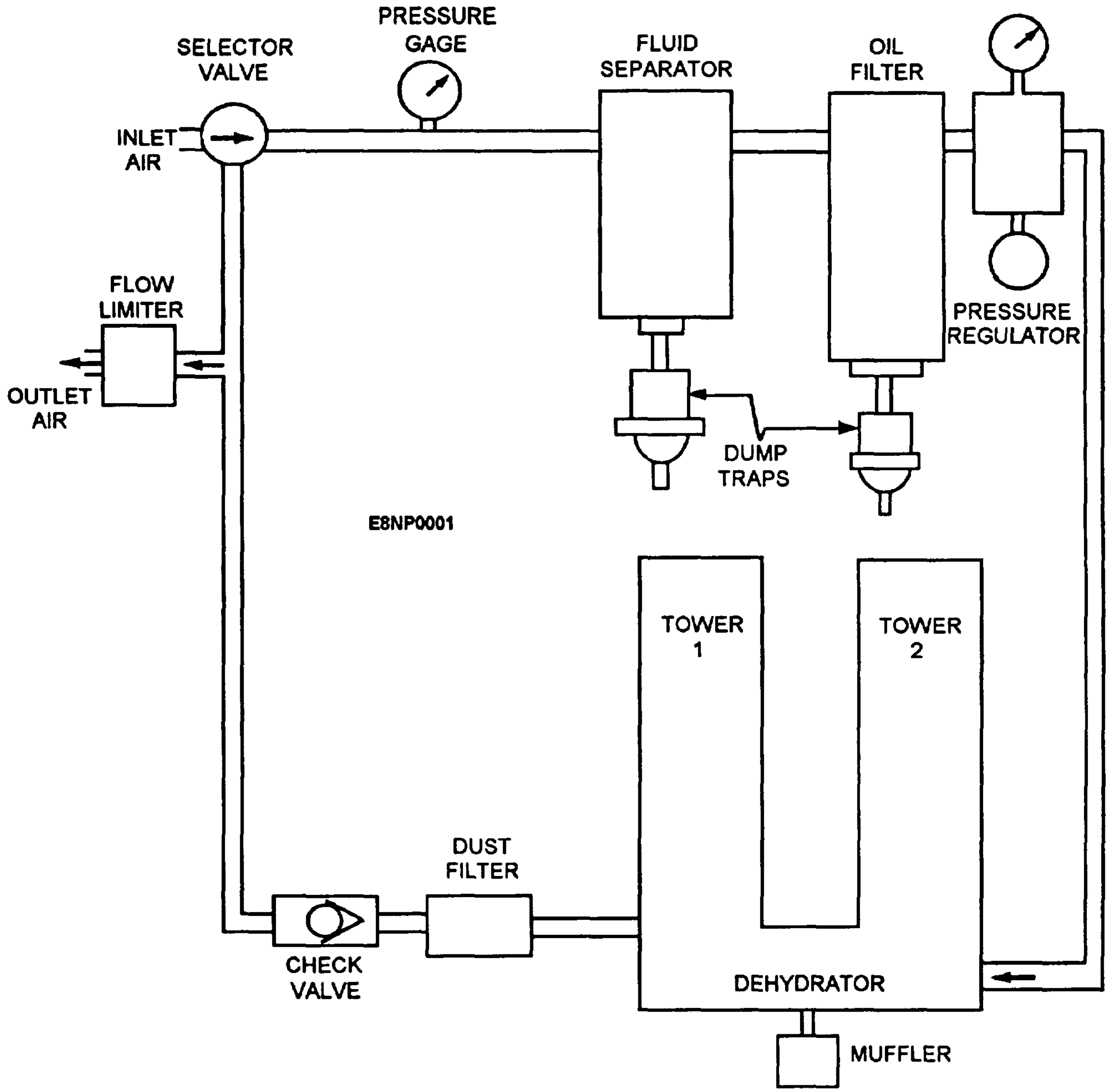

Figure 2-1.-Desiccant air dryer.

After the fluid separator, the air is passed through a telltale oil filter, which removes oil through a combination of mechanical means and absorption. The oil that is removed mechanically drains into a dump trap and is discharged into a waste line as in the fluid separator.

The oil that is absorbed causes the absorbing material to change color from pink to deep red, starting at the bottom, as it becomes saturated. Since the absorbing column is in a transparent plastic tube, the color change is visible. Before the color change reaches the red line on the column, the absorbing material is discarded and new material is installed.

At this point, liquid oil, liquid water, and some oil vapor have been removed from the air. The air is, in most cases, still saturated with water vapor and still contaminated with oil vapor.

After passing through a pressure regulator, which reduces the air pressure and holds it constant, the wet air passes through the most important unit of the system—the purifier-dehydrator. The purifier-dehydrator performs a cleaning step by a process known as adsorption There is a difference between absorption and adsorption.

Absorption takes place in the telltale oil filter when it removes oil by soaking it up as a liquid (the same way that a sponge absorbs liquid water into its interior pores).

Adsorption is a surface and a molecular phenomenon. Mobile gaseous and liquid atoms or molecules are attracted to the surface of any solid because of unbalanced forces existing at the surface. Good absorbents are those that present large surfaces per unit and have high attractive forces. One cubic inch of the adsorbent material used in this dryer has an adsorbent area greater than the area of two football fields.

The wet air passes through chambers filled with a molecular sieve type of desiccant, or adsorbing material. Vapor molecules are left behind on the desiccant and the air emerges clean and dry.

The dehydrator has two such chambers through which the air passes alternately. While one chamber is removing vapor from the air, a small portion of the dried air is routed through the second chamber to purge it of all collected vapors and to prepare it to do the drying during the next half cycle.

The reactivation of the desiccant is completely automatic, and unless slugs of entrained water or oil are permitted to enter the desiccant chambers, the material should not be replaced except at major overhaul. The fluid separator and the telltale oil filter, located upstream, prevent slugs of liquid from reaching the desiccant if they are kept in good operating condition.

The dust filter, located downstream from the dehydrator, removes any desiccant or other dust particles that might otherwise be carried along in the dry airstream. At the outlet of the drier unit, a flow limiter is used to prevent the electronic equipment from exceeding the capacity of the dryer. In normal operation, the flowmeter has no effect. However, should an air line or waveguide downstream from the dryer be opened, the flow limiter would prevent an excessive airflow beyond the capability of the dryer.

DRYER COMPONENTS

In figure 2-1, the placement of the individual components is shown for a typical dryer. This is the order that you should expect to see them. The air dryer is a very reliable piece of equipment and with proper PM can give you years of service.

The operation of the dryer can be bypassed by changing the selector valve. With the selector valve in the position as shown, all air is routed through the dryer.

Starting at the inlet, the individual operation of each major component will be discussed in depth. Let's begin with the fluid separator and its dump trap.

Fluid Separator and Dump Trap

The fluid separator and dump trap consist of two interconnected assemblies, the separator and the automatic trap, connected together as shown in figure 2-2. The separator itself is a welded metal tank within

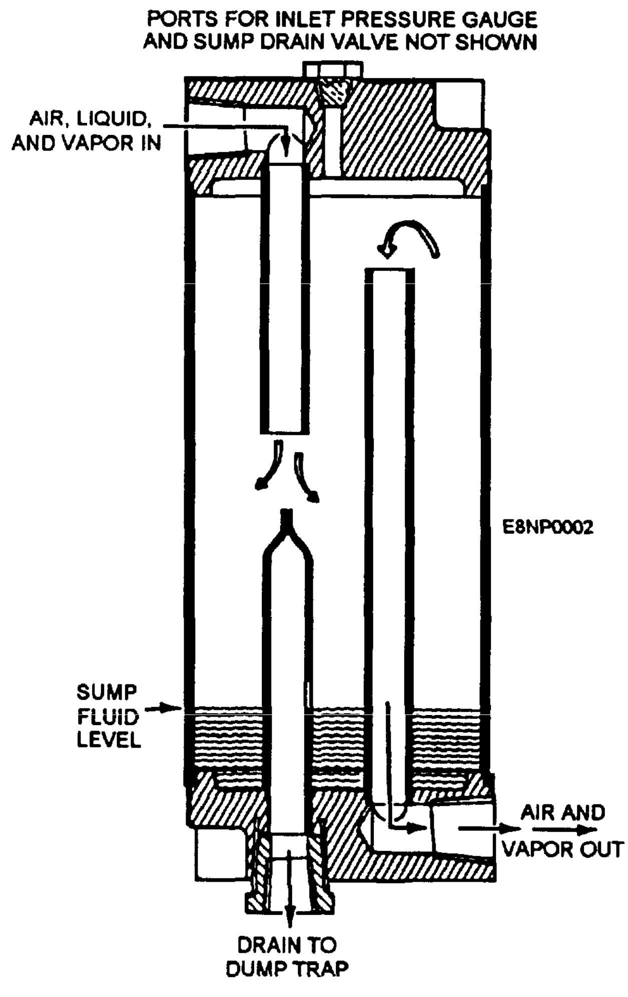

Figure 2-2.—Fluid separator.

and out ports, an inlet pressure gauge, a dump trap, and a sump drain port. There is also a pipe plug located in the top for testing the dump trap.

Air flows through the in-port and a down-coming tube, and is exhausted into the tank. It then reverses its direction, flows upward to the top of the out-port tube, and reverses direction again to reach the Out-port.

Centrifugal forces at the two points of reversal and the slowing of the flow within the tank extract the entrained droplets of liquid. These droplets collect at the bottom of the tank and drain into the dump trap. When the liquid level in the trap rises sufficiently, a float (through a connecting linkage) opens a valve to a waste line, and the collected liquid is blown out. When the float drops, the valve closes and liquid collects until the float automatically initiates another disposal sequence.

Operation of the float maybe observed through a transparent trap bowl. The trap is also equipped with a manual drain, which is operated by pulling a button on the bottom of the trap.

Telltale Oil Filter and Dump Trap

The telltale oil filter and dump trap are located downstream from the fluid separator and dump trap. It is designed specifically to remove oil from compressed air and to indicate by color the state of the oil removing material. This unit further purifies the air by removing small oil droplets that escape the fluid separator.

As shown in figure 2-3, the filter employs two direction changes of airflow and impingement surfaces to mechanically remove droplets; a mist separator to help small drops become larger and drop out; and an absorbing material to remove the remainder. The absorbing column, which is visible in a transparent tube, changes color from pink to dark red as it absorbs oil. Before the color change reaches a redline indicator, the filter element should be replaced.

Liquid oil drains are collected into an automatic dump trap for discharge into a waste line. This trap is identical to that used on the fluid separator; therefore, the same explanation and comments apply.

The combination of the fluid separator and the telltale oil filter removes entrained water and oil and some of the oil vapor from the supply air, provided that these units are properly maintained. Water vapor and any remaining oil are removed in the dehydrator (fig. 2-1), which follows further downstream.

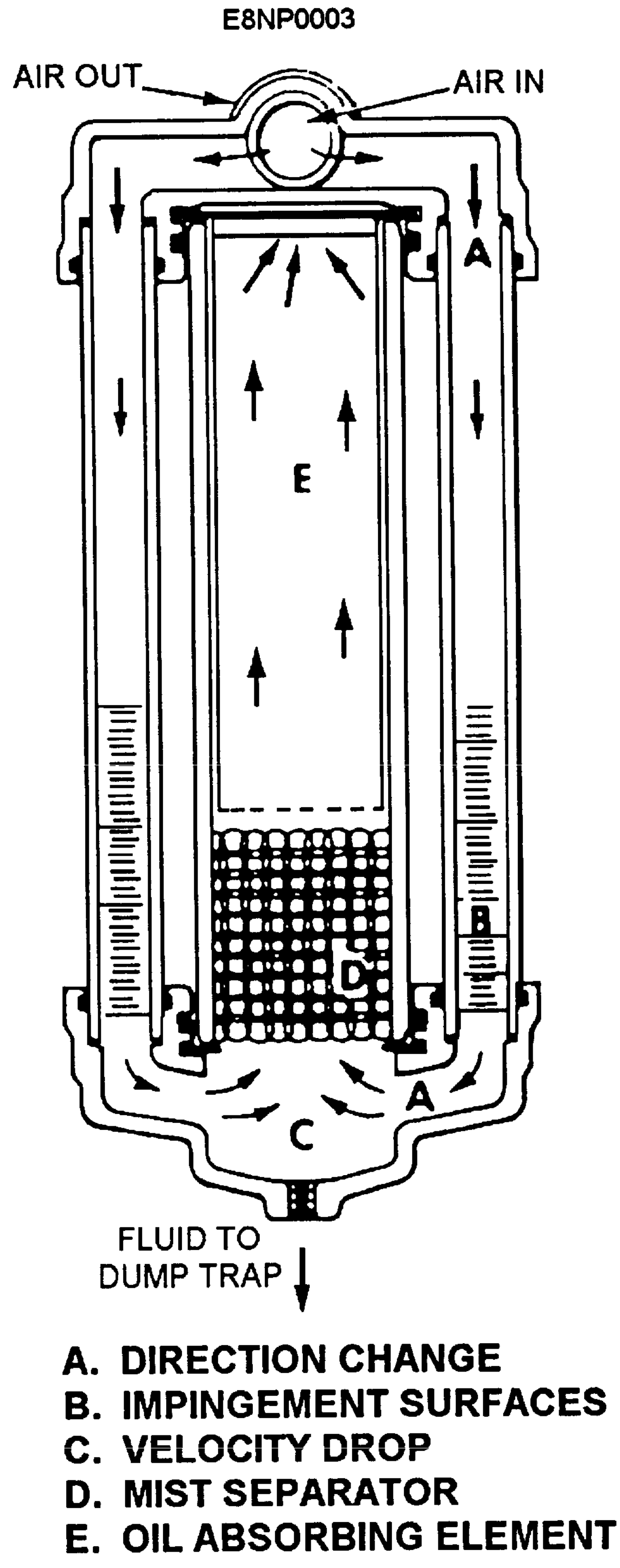

Figure 2-3.-Telltale oil filter.

Pressure Regulator

The pressure regulator (fig. 2-4) is a diaphragm-operated, pressure-reducing valve located downstream from the fluid separator and telltale oil filter. The diaphragm position governs the valve opening, maintaining a constant reduced output pressure. Compressed air is used to load the diaphragm. This is accomplished by bleeding air from the line through two needle valves, the body needle valve and the dome needle valve, into the air dome. These two needle valves are used to seal off or trap air in the air dome at a pressure approximately equal to the desired outlet pressure. Since the air dome pressure is approximately equal to desired outlet pressure, a O- to 100-psig meter is installed, which constantly monitors air dome pressure. This pressure is factory adjusted to 80 psig, which is the inlet pressure to the dehydrator unit.

Since the dome is sealed after loading, a change in temperature will cause a slight change in dome pressure, with a corresponding shift in outlet pressure. ‘his outlet pressure shift amounts to about 1 psig for each 5 degrees Fahrenheit.

The pressure regulator is a balanced pressure regulator that is actuated by static gas pressure in a sealed dome. There is a flexible diaphragm between the

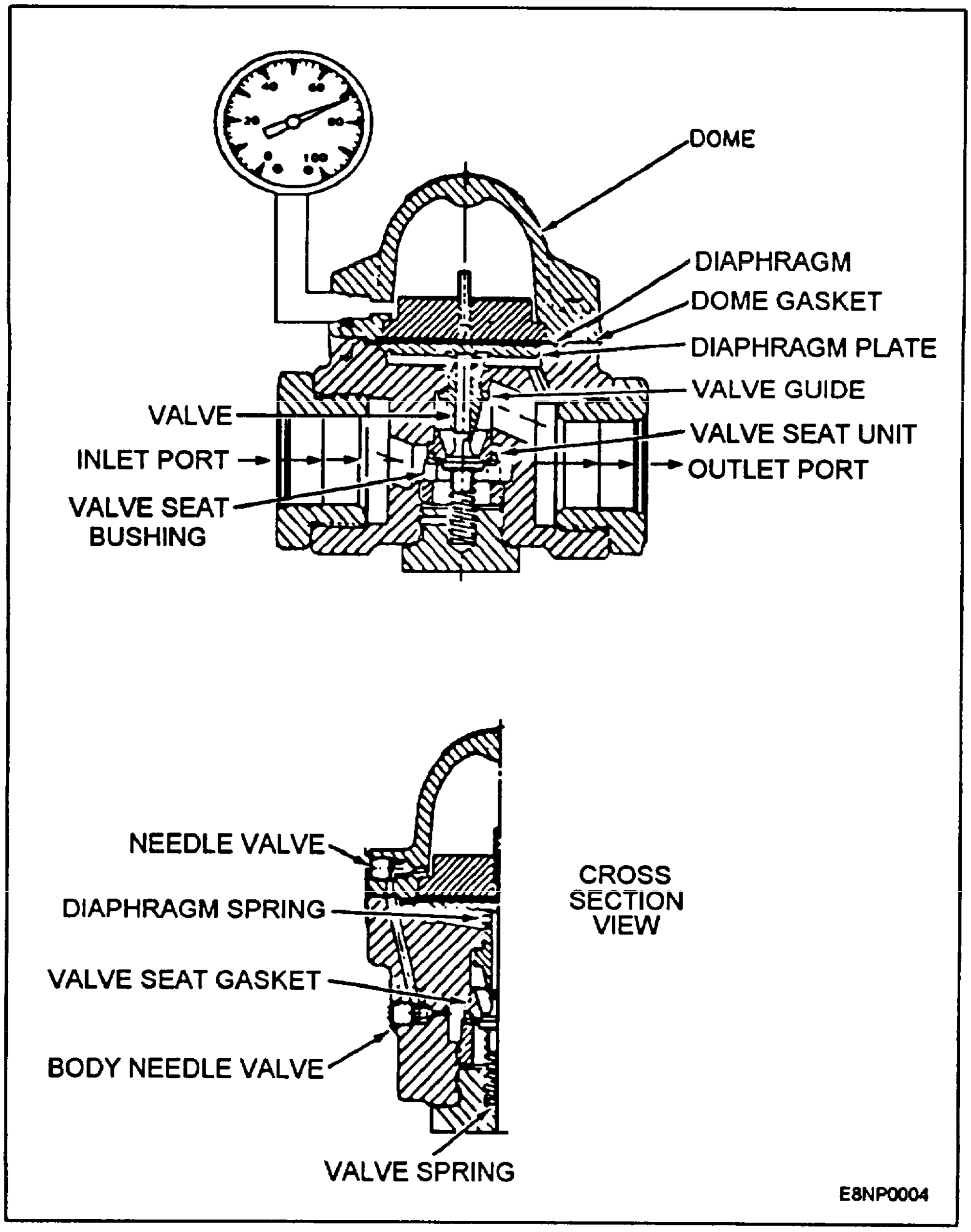

Figure 2-4.-Pressure regulator.

sealed dome and the outlet line fluid. When outlet line pressure drops below dome pressure, the diaphragm moves out slightly and pushes the main valve open. This allows inlet line gas to flow through the valve until outlet line pressure builds up enough to balance the dome pressure. Then, the diaphragm moves back to throttle or closes the main valve so that dome and outlet pressures always remain in balance.

Any change in dome pressure causes a corresponding change in outlet line pressure. When the dome is completely vented, the main valve shuts off bubble tight.

Any trouble with the pressure regulator can usually be traced to the valve and valve seat, or to the diaphragm and O-rings being worn or deteriorated.

Dehydrator

The dehydrator (fig. 2-5) consists of two desiccant chambers filled with desiccant in the form of small spheres. The desiccant chambers are supported by the manifold, and they are connected to the manifold by internal air passages. A pair of two-way solenoid valves are attached to the bottom side of the manifold.

The program timer controls the operation of the two solenoid valves. In one 60-second period, each solenoid valve is open for 22 seconds and closed for 38 seconds. The timing for the solenoid valves is such that both valves are closed for two 8-second dwell phases. One complete cycle takes place in each desiccant chamber every 60 seconds.

Dry air is needed for reactivation of the desiccant chambers. A small quantity of dry air (figs. 2-5 and 2-6, phase I) is bypassed around the ball-check valve by a

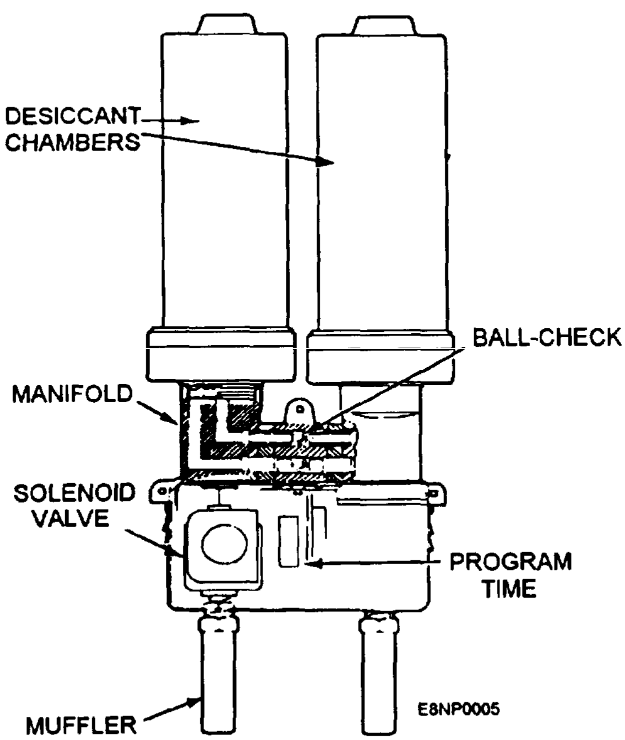

Figure 2-5.—Dehydrator.

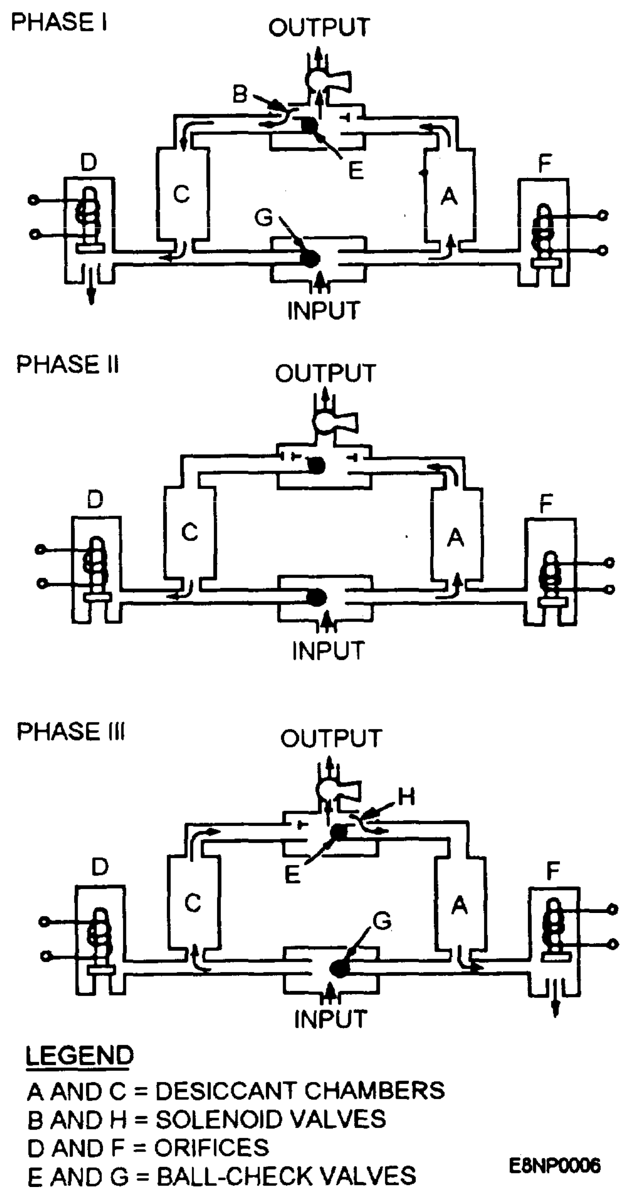

Figure 2-6.—Dehydrator operating cycle.

fixed orifice (B) in the valve body for this purpose. It is expanded to atmospheric pressure through the fixed orifice, which controls the purge airflow. The purge air back flows to atmosphere through each desiccant chamber during half of each cycle. The dry purge air enters the top of the chamber. The oil and water that are removed from the chamber are discharged from the bottom of the chamber through the purge muffler.

The key to the simplicity and unusual efficiency of the dehydrator is its unique valving system. A particular point to notice is that the solenoid control valves handle only the purged air. (The main airflow through the unit does not pass through them as in older units employing three-way valves.) This means that simple, direct-acting, large-orifice, two-way valves can be used to eliminate the sources of high-pressure drops. In addition, this type of valve is more dependable.

Let us take a detailed look at the operation of a dehydrator. We'll consider a complete cycle of operation. Refer to figure 2-6, phases I, 11, and III for the following descriptions.

PHASE I—DRY/PURGE.— The solenoid valve (F) is closed. Solenoid valve (D) is open. Incoming moist air, under pressure, flows through chamber (A), where it is dried. Most of this dry air is passed through the outlet conduit to be put to use. A small quantity, however, bypasses the closed ball-check valve (E) through a small orifice (B) into chamber (C). Here it picks up moisture from the partially saturated desiccant and passes out of the unit through the open valve (D). Since the chamber being purged is at near-atmospheric pressure, the ball-check valves (E) and (G) are held in place by the pressure of the main airflow.

PHASE II—DWELL.— The timer closes both solenoid valves (D) and (F). This allows the pressure in the regenerated chamber (C) to build up through the orifice to approximately that of chamber A.

PHASE III—DRY/PURGE.— In figure 2-6 (phase III), the solenoid valve (F) is opened by the timer; solenoid valve (D) remains closed. The pressure in chamber (A) drops immediately, causing the ball-check valves (E) and (G) to move rapidly to the right, sealing off chamber (A) and directing the main airflow through chamber (C) where it is dried. A portion of this dry air, leaking through orifice (H), passes through chamber(A) where it picks up moisture and is emitted to the atmosphere through valve (F). After completing another dwell period, the cycle repeats.

The most important single aspect of maintaining the dehydrator is to assure proper operation of the automatic dump traps on the fluid separator and the telltale oil filter units. If oil, water, and sludge are not expelled the accumulated liquids may fill the trap, back up into the air lines, and pass into the dehydrator. Complete failure of the desiccant material of the dehydrator to dry and purify quickly follows. If this happens, you will have to completely disassemble and clean the fluid separator, telltale oil filter, both dump traps, the pressure regulator, the dehydrator, and all the interconnecting piping. Also, the desiccant in the dehydrator chambers will have to be replaced.

Dust Filter

The dust filter (fig. 2-1) consists of a separable housing, which contains a replaceable falter cartridge, constructed of pleated paper (5 microns). The design is such that air flows from the outer (housing) side inward to a hollow center that is connected to the outlet port. Dust is then collected on the outer surface of the filter cartridge. Since the collected dust is dry, any substantial accumulation falls to the bottom of the housing and lessens the possibility of clogging the filter.

Flow Limiter

A flow limiter (fig. 2-1) is installed between the dust filter and output of the dryer. It is designed to limit the output of the dryer, should the output of air increase beyond the limits of the dryer capability.

The flow limiter is a spring-restrained poppet valve with an orifice in the poppet valve. The poppet valve offers no appreciable resistance to the flow of air during normal operation. When the flow exceeds the design of the dryer, the poppet valve closes, and the flow is then limited by the orifice in the poppet valve.

MOISTURE MONITOR

A moisture monitor probe is installed downstream from the dryer to monitor the dew point of the dry air. The monitor gives you a visual reading in ppm (parts per million) or in dew point (for example, 40°F). Most monitors have a built-in alarm system. It provides both audible and visual alarms when the air quality is less than the value that it is set to.

When the monitor unit is designed to read the moisture content of the air in dew point, a conversion chart is included with the unit. 'This chart converts the individual reading to a standard dew-point reading, which is at atmospheric pressure; for example, a dryer feeding three waveguide systems at 10, 20, and 30 psig.

You take a reading of the dew point on the three different waveguide systems and come up with -32°, -25°, and -21°F, respectively. Is the last reading of -21°F a good reading? The radar equipment manual specified -25°F as the minimum requirement (at atmospheric pressure). Using the dew-point conversion chart, all three of the above readings convert to 4°F, which is well within tolerance for the radar.

The conversion chart is used to convert the individual dew-point reading at various pressures to a known standard.

The sensor probe, which is used to monitor the dry air, consists of an aluminum strip that is anodized by a special process to provide a porous oxide layer. Avery thin coating of gold is evaporated over this structure. The aluminum base and the gold layer form the two electrodes of what is essentially an aluminum oxide capacitor. Water vapor is rapidly transported through the gold layer and equilibrates (is in equilibrium) on the pore walls in a manner functionally related to the vapor pressure of water in the atmosphere surrounding the sensor.

The number of water molecules absorbed on the oxide structure determines the conductivity of the pore wall. Each value of pore wall resistance provides a distinct value of electrical impedance; which, in turn, is a direct measure of water vapor pressure.

The monitor unit, as we have indicated, is usually a complex impedance meter. It applies a low-frequency signal of less than 100 Hz to the sensor probe. By measuring the change in this signal amplitude and phase, caused by the sensor probe, the monitor unit continuously computes the impedance of the probe and then displays the value on the unit's meter as the dew point.

Most moisture monitors do not require routine maintenance. If a malfunction should occur, you should isolate the problem by substituting a sensor probe (known to be good). (The sensor is extremely fragile and nothing should touch the aluminum oxide element.) If the problem is isolated to the monitor unit and not the sensor probe, you should use the unit's schematic diagrams and a multimeter to isolate the problem.

SUMMARY

In this chapter, you were given a brief overview of electronics dry air and various types of systems. You have been introduced to a typical shipboard dry air system and its major components: fluid separator, telltale oil filter and dump trap, pressure regulator, dehydrator dust filter, flow limiter, and moisture monitor. These topics have provided you with the fundamental knowledge of their operation so that after some hands-on training you can operate and maintain them with confidence.